The same paper is adapted to the AMERICAN NATURALIST for December, 1879, pp. 771*a–j*, with eight cuts.

Pages 798*a–b*, of AMERICAN NATURALIST for December, give in brief some of the more important results of Mr. Cope's recent trip to the Pacific coast, describing among other things the remarkable new fossil cats, *Archælurus debilis* and *Hoplophoneus platycopis*.

Mr. Cope's Palæontological Bulletin, No. 31, being a "Second Contribution to a Knowledge of the Miocene Fauna of Oregon," "read before the American Philosophical Society, December 5, 1879," contains descriptions of the following new fossil mammals: *Hesperomys nematodon*, *Sciurus vortmani*, *Canis lemur*, *Chænohyus* (g. n.) *decedens*, *Thinohyus trichænus*, *Palæochœrus subæquns*, *Coloreodon* (g. n.) *ferox*, *C. macrocephalus*. The date of printing is given as December 24, 1879.

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A REVIEW OF THE MODERN DOCTRINE OF EVOLUTION.[1]

BY E. D. COPE.

THE doctrine of evolution of organic types is sometimes appropriately called the doctrine of derivation, and its supporters, derivatists. This is because it teaches the derivation of species, genera and other divisions, from pre-existent ones, by a process of modification in ordinary descent by reproduction. The opposite or creativist doctrine teaches that these forms were created as we see them to-day, or nearly so; and that the natural divisions and species of organic beings have never been capable of change, the one into the other.

I. The Evidence for Evolution.

The reasons which induce me to accept the derivatist doctrine, and to reject the creational, fall under the two heads of probabilities and conclusive evidence. The probabilities are cumulative in their pointings, and form part of a total body of evidence which is, to my mind, conclusive. The reasons why derivation is probable are the successional relation of increment or decrement of structure, observed in:

[1] Abstract of a lecture delivered before the California Academy of Sciences, Oct. 27, 1879.

1. Systematic relation (taxonomy); 2. Embryonic growth (embryology); 3. In geologic time (palæontology); 4. And in the coincidence in the successions seen in Nos. 1, 2 and 3.

The fact that it is necessary to arrange animals in an order corresponding with the phases of their embryonic history is remarkable; but the further fact, shown by palæontology, that the same succession marked the ages of past time, at once brings evolution within the limits of strong probability. Nevertheless, all this might have been a mere system, without transitions between its members; organic types might have been created unchangeable, but presenting the mutual relations in question. But if transitions among these members can be shown to take place, then indeed the phenomena mentioned receive a sufficient explanation. They are seen to be the necessary relations of the parts of a shifting scene of progression and retrogression; they express combinations of structure, which, though often long enduring, are, nevertheless, not perpetual, but give way to other combinations to be in their turn dissolved. Now, if there is anything well known in nature, it is that there are divisions of various ranks in the vegetable and animal kingdoms, whose contents present variations of structure which are confessedly additions to or subtractions from the characters of ancestors, which have appeared during ordinary descent. The protean species, genera, etc., are well known to biologists, and every naturalist who admits varieties, sub-species, sub-genera, etc., admits derivation so far as they are concerned. The facts of variation, including "sporting," etc., are notorious, not only among domesticated, but also in wild animals and plants. The facts have led some persons to suggest that species have been produced by evolution from a single specific center, but that the genus and other comprehensive divisions are unchangeable. But I think I have shown, in a paper entitled, "The Origin of Genera,"[1] that the structural characters which define genera, and even higher divisions, are subjects of variation to as great an extent as are the less profound specific characters; and, moreover, that the evidence of derivation which they present is singularly clear and conclusive. The changes of both genus and species character are always of the nature of additions to or subtractions from those of one generation displayed by their descendants. As such, they form the closing chapters of the embryonic or growth-history of the modified generation.

[1] Philadelphia, 1869. "Proceedings Academy Natural Sciences, 1868."

In order to explain more fully the application of the above statements, I introduce a few examples selected from the subjects of my studies. Their number might be indefinitely extended. I first cite the genera of the tailless *Batrachia Anura* (frogs, toads, etc.), whose relations are very simple and clear, and show the parallelism between adult structure and embryonic succession. See above, 1 and 2.

The greater number of *Batrachia Anura* fall into two divisions, which differ only in the structure of the lower portion of their scapular arch, or shoulder girdle. In the one the opposite halves are capable of movements which contract or expand the capacity of the thorax; in the other the opposite halves abut against each other so as to be incapable of movement, thus preserving the size of the thoracic cavity. But during the early stages, the frogs of this division have the movable shoulder girdle which characterizes those of the other division, the consolidation constituting a modification superadded in attaining maturity. Furthermore, young *Anura* are toothless, and one section of the species with embryonic shoulder girdle never acquire teeth. So here we have a group which is imperfect in two points instead of one. This is the tribe *Bufoniformia;* the tribe with teeth and embryonic shoulder girdle is called the *Arcifera*, and that which is advanced in both these respects is the *Raniformia*. Now the frogs of each of these divisions present nearly similar scales of development of another part of the skeleton, viz: the bones of the top of the skull. We find some in which one of these bones (ethmoid) is represented by cartilage only, and the fronto-parietals and nasals are represented by only a narrow strip of bone each. In the next type the ethmoid is ossified; in the next, we have the fronto-parietal completely ossified, and the nasals range from nar-

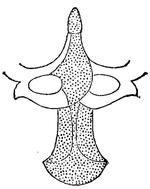

FIG. 1.

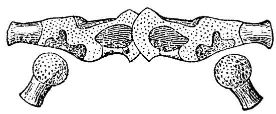

FIG. 2.

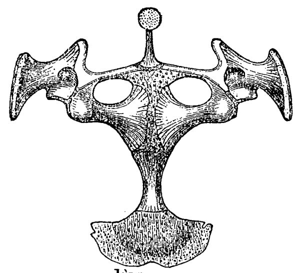

FIG. 3.

Shoulder girdles of *Anura*. Fig. 1, of the Arciferous type (*Scaphiopus holbrooki*). Fig. 2, *Rana temporaria*, tadpole with budding limbs. Fig. 3, do. adult. Figs. 2 and 3 from Parker.

row strips to complete roofs; in the fourth station on the line, these bones are rough, with a hyperostosis of their surfaces; and in the next set of species, this ossification fills the skin, which is thus no longer separable from the cranial bones; in the sixth form the ossification is extended so as to roof in the temporal muscles and enclose the orbits behind, while in the rare seventh and last stage, the tympanum is also enclosed behind by bone. Now all of these types are not found in all of the families of the *Anura*, but the greater number of them are. Six principal families, four of which belong to the *Arcifera*, are named in the diagram below, and three or four others might have been added. I do not give the names of the genera which are defined as above described, referring to the explanation of the cuts for them, but indicate them by the numbers on the left margin of the page, which correspond to those of the definitions above given. A zero mark signifies the absence or non-discovery of a generic type.

	Sternum embryonic.				Sternum complete.
	Bufoniformia.	Arcifera.			Raniformia.
	Bufonidæ.	Scaphiopidæ and Pelobatidæ.	Cystignathidæ.	Hylidæ.	Ranidæ.
1—	0	0	1	1	0
2—	2	2	2	2	0
3—	3	0	3	3	3
4—	4	4	4	4	4
5—	5	5	0	5	5
6—	6	6	6	6	0
7—	7	0	0	0	0

It is evident, from what has preceded, that a perfecting of the shoulder-girdle in any of the species of the Bufoniform and Arciferous columns, would place it in the series of *Raniformia*. An accession of teeth in a species of the division *Bufoniformia*, would make it one of the *Arcifera*; while a small amount of change in the ossification of the bones of the skull would transfer a species from one to another of the generic stations represented by the numbers of the columns from one to seven.

There are few groups where this law of parallelism is so readily observed among cotemporary types as the *Batrachia*, but it is none the less universal. The kind of parallelism usually observed is that in which there is only a partial resemblance between adults of certain animals and the young of others. This has been termed

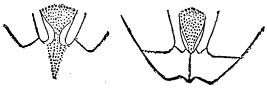

FIG. 2.

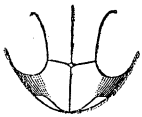

FIG. 3³.

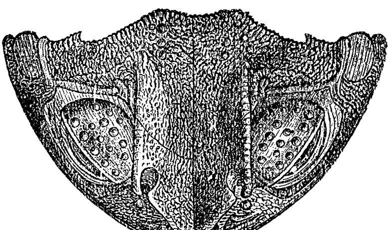

FIG. 6.

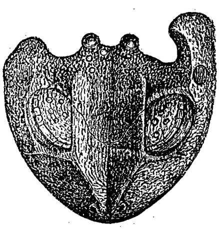

FIG. 7.

BUFONIDÆ.

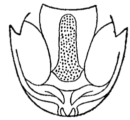

FIG. 2.

FIG. 3, wanting.

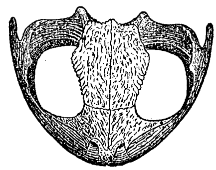

FIG. 5.

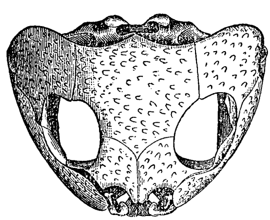

FIG. 6.

FIG. 7, wanting.

SCAPHIOPIDÆ AND *PELOBATIDÆ.*

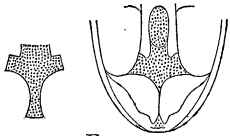

FIG. 1.

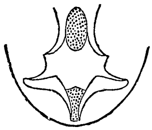

FIG. 2.

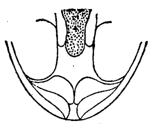

FIG. 2^1.

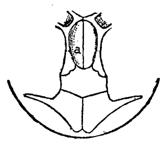

FIG. 3^2.

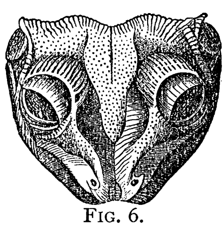

FIG. 6.

HYLIDÆ.

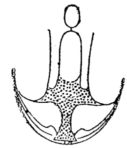

FIG. 1.

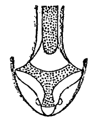

FIG. 2.

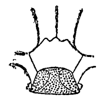

FIG. 3.

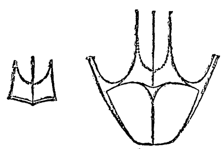

FIG. 3^2.

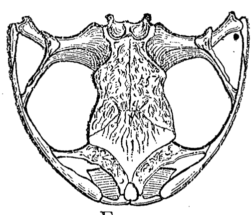

FIG. 4.

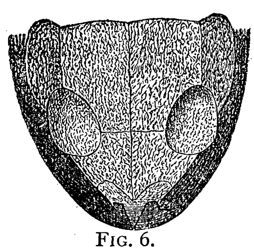

FIG. 6.

CYSTIGNATHIDÆ.

"inexact parallelism," and the relation is presented by forms not very nearly phylogenetically related. The more remote the phylogenetic lines of two types, the more "inexact" will their parallelism be. It was once a question whether any parallelism can be traced between the members of the five or six primary divisions of animals, and in my essay on the "Origin of Genera," I was compelled to state that there was then "no evidence of the community of origin of these divisions." Since that time, Haeckel has published his "Gastræa Theory." This is a grand generalization from the facts of embryology, which shows the community in type of the early stages of all animals, and the similarity of the phases which they present during a part of their larval life. The exceptions to this law which have been observed, will probably be explained, as have been those which have been urged against the law of homologies in anatomy.

FIG. 3$_{-1}$.

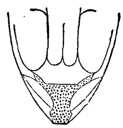

FIG. 3.

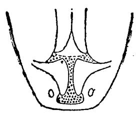

FIG. 3^1.

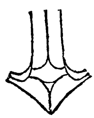

FIG. 3^2.

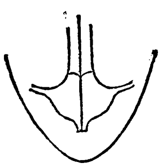

FIG. 3^3.

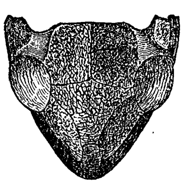

FIG. 5.
RANIDÆ.

The palæontology of the *Batrachia Anura* is largely unknown, so we must look elsewhere for proof of the truth of the fourth proposition, viz., that the successional relation in embryology corresponds with that shown by palæontology to have existed in geologic time.

For this purpose I select one of the most complete series known to palæontology; that of the camels or *Camelidæ*, whose remains are found abundantly in various parts of our country. The succession of the known genera is seen in the structure of the bones of the feet, and of the superior incisor and premolar teeth. The metatarsal and metacarpal bones are or are not coössified into a cannon bone; the first and second superior incisor teeth are present, rudimental or wanting, and the premolars number from four to one. The relations

which these conditions bear to geologic time is displayed in the following table, commencing with the lowest horizon:

	No cannon bone.	Cannon bone present.		
	Incisor teeth present.	Incisors one and two wanting.		
	4 premol'rs.	3 prem'rs.	2 prem's.	1 prem'r.
Lower Miocene.	*Poëbrotherium.*			
Upper Miocene.	*Protolabis.*			
	Procamelus.			
		Pliauchenia.		
Pliocene and Recent.			*Camelus.*	
				Auchenia.

This table shows that geological time has witnessed, in the history of the *Camelidæ*, the consolidation of the bones of the feet and a great reduction in the numbers of the incisor and premolar teeth. The embryonic history of these parts is as follows: In the fœtal state all the *Ruminantia* (to which the camels belong) have the cannon bones divided as in *Poëbrotherium;* they exhibit also incisor teeth, as in that genus and *Protolabis.* Very young recent camels have the additional premolar of *Pliauchenia.* They shed this tooth at an early period, but very rarely a camel is found in which the tooth persists. The anterior premolar of the normal *Camelus* is in like manner found in the young lama (*Auchenia*), but is shed long before the animal attains maturity. I may add that in some species of *Procamelus* caducous scales of enamel and dentine in shallow cavities represent the incisive dentition of *Protolabis.*

It remains to shows that characters of the kind above mentioned are sometimes inconstant; that they may or may not appear in individuals of a species. Under such circumstances it is evident that their origin does not imply any break in the line of descent.

First, as to a family character. It is well known that the deer differ from the giraffes in the presence of a burr or ring of osseous excressences surrounding the base of the horn. Now in the extinct tertiary genus *Cosoryx* there are three species which possess or lack this burr indifferently. Why some individuals should, and others should not possess it, is not known.

Second, as to a generic character. The genus *Canis* (dog) is defined by the presence of two tubercular molars in the inferior series. The allied genus *Thous*, possesses three such teeth, while

Icticyon has but one. Now examples of *Canis familiaris* (domestic dog) with but one tubercular molar are not rare, while an individual with three is occasionably found.

To take another case. The normal dentition of *Homo* (man) is, on each side, incisors, 2 ; canine, 1 ; premolars, 2 ; molars, 3. It is very common to find in the higher races, individuals who have molars only two in one or both jaws; and the absence of the external incisors of the upper jaw is almost as frequently met with. Here we have two new generic variations in one and the same species.

In specific characters variations are most familiar. Thus, the young of deer are generally spotted, and the adults are nearly uniform in coloration. Some deer (as the *Axis*) retain the spotted coloration throughout life, while an occasional spotted individual of unicolor species, is a violation of specific character by a failure to develop. The larvæ of some salamanders are of uniform coloration, and the adults spotted. The unicolor adults of the same species, not uncommonly met with, present examples of the same kind of variation.

Any biologist can select hundreds of similar cases from his special department of study.

II. The Laws of Evolution.

Having reviewed the reasons why the doctrine of evolution should be received as truth, I desire to give attention to the laws which may be made out by reference to its phenomena. Progress in this direction is difficult, owing to the natural impediments in the way of studying the history of the growth of living beings. We will, however, commence by examining more fully the phenomena with which we have to deal.

It is well understood that the world of animal life is a nicely adjusted equilibrium, maintained between each individual and its environment. This environment exerts forces both purely physical, and those exercised by other animals. Animals antagonize each other in procuring food, whether that food consist of vegetation or of other animals, but in the latter case the conflict is more severe. A similar competition exists among male animals in the matter of reproduction. These exhibitions of energy constitute the struggle for existence, which is the daily business of the living world. It is well understood, that in this struggle the individuals best provided with means of self-preser-

vation necessarily survive, while the weak in resources must disappear from the scene. Hence those which survive must display some especial fitness for existence under the circumstances of their environment, whatever they may be. So the "survival of the fittest" is believed to be a law of evolution, and the process by which it is brought about has been termed "natural selection." The works of Darwin and others have satisfied biologists that this is a *vera causa*.

Before the excellence of a machine can be tested, it must exist, and before man or nature selects the best, there must be at least two to choose from as alternatives. Furthermore it is exceedingly improbable that the nicely adapted machinery of animals should have come into existence without the operation of causes leading directly to that end. The doctrines of "selection" and "survival" plainly do not reach the kernel of evolution, which is, as I have long since pointed out, the question of "the origin of the fittest." The omission of this problem from the discussion of evolution, is to leave Hamlet out of the play to which he has given the name. The law by which structures originate is one thing; those by which they are restricted, directed, or destroyed, is another thing.

There are two kinds of evolution, progressive and retrogressive; or, to use expressions more free from objection, by addition of parts, and by substraction of parts. It is further evident that that animal which adds something to its structure which its parents did not possess, has grown more than they; while that which does not attain to all the characteristics of its ancestors has grown less than they. To express the change in the growth-history which constitutes the beginning of evolution, I have employed the terms "acceleration and retardation." Generally these expressions are literally exact, *i. e.*, there is an increased rate of growth in evolution by addition, and a decreased rate in evolution by subtraction; but this is not always the case, for some divisions of animals have increased the length of their growth-period without reference to evolution in structure. The terms express the phenomena figuratively, where not exact in the sense of time, and I believe they are sufficiently clear. The origin of the fittest is then a result of either acceleration or retardation. It is easy to perceive that a character which makes its appearance in a parent before or near to the breeding season is likely to be

transmitted to its descendants; so also a character which is lost near this time is likely to be wanting from the offspring. The causes of acceleration and retardation may next claim attention.

It is well known that the decomposition of the nutritive fluids within living animals gives rise, in the appropriate tissues, to exhibitions of different kinds of forces. These are, motion in all classes; heat in some only; in a still smaller number, electricity and light; in all, at certain times, growth-force or bathmism; in many, phrenism or mental or thought-force. These are all derived from equivalent amounts of chemical force which are liberated by the dissolution of protoplasm. This organic substance, consisting of CHON, undergoes retrograde metamorphosis, being resolved into the simpler CO_2, HO, etc., and necessarily liberates force in the process. None of the functions of animal life can be maintained without supplies of protoplasm. We have here to do with bathmism. It consists of the movement of material to, and its deposition in, certain definite portions of the growing egg, or fœtus, as the case may be. It is different in its movements in every species, and its direction is probably the resultant of a number of opposing strains. In the simplest animals its polar equilibrium is little disturbed, for these creatures consist of nearly globular masses of cells. As we ascend the scale a greater and more marked interference becomes apparent; radiated animals display energy in a number of radiating lines rather than in the spaces between them; and in longitudinal animals, a longitudinal axis exceeds all others in extent and importance. In the highest animals its results are much more evident at one extremity of the axis (head) than at the other, and the diverging lines are reduced to four (the limbs). In each species the movements of this force are uniform and habitual, and it is evident that the habit is so deeply seated that only a very strong dynamic interference can modify or divert it. The interfering forces are probably all those transmissible through living tissue, and especially molar force. Thus every species has its own specific kind of bathmic force.

The characters of living beings are either adaptive or non-adaptive; they are either machines especially fitted to meet the peculiarities of their environment, or they are not. Among the latter may be ranged rudimental structures and also many others

of no sufficient use. They are all due either to excess or defect of growth force; they are either consequences of a removal of nutritive material to other portions of the body; or they are due to an excess of such material which renders an organ or part useless through disproportionate size. Of the former class may be cited the absence of the tail in some monkeys and birds; also of the teeth in some Cetaceans; of the latter kind are the enormous tusks of the mammoth and the recurved superior canines of the babyrussa. The change of destination of this material has been probably due to the construction of adaptive machines whose perfection from time to time has required the use of larger and larger proportions of force and material.

In considering the origin of adaptive structures, two alternative propositions are presented to us. Did the occasion for its use follow the appearance of the structure, or did the need for the structure precede its appearance? The following answer to the question has always been the most intelligible to me. Animals and plants are dependent for existence on their environment. It is an every-day experience that changes in environment occur without any preparation for them on the part of living things. If the changes are very great, death is the result. It is evident that the influence of environment is brought to bear on life as it is, or has been, and that special adaptations to it on their part must follow, not precede changes of climate, topography, population, etc. We have another important consideration to add to this one, viz: the well-known influence of use, *i. e.*, motion, on nutrition. Exercise of an organ determines nutritive material to it, and the nervous or other influence which does this, equally determines nutritive material to localities in the body to which an effort to move is directed, whether an executive organ exist there or not. The habit of effort or use determining the nutritive habit must be inherited, and result in the growing young, in additional structure. Change of structure, denied to the adult on account of its fixity, will be realized in the growing or plastic condition of fœtal or infant life. The two considerations here brought forward lead me to think that the cause of acceleration, in many adaptive structures, is environment alone, or environment producing movements, which in turn modify structure. The character of the stimulus in the successive grades of life may be expressed by the following table, passing from the lowest to the highest:

1. Passive or motionless beings;
   by climate and food only.
2. Movable beings;
   by climate, food and motion.

   By motion either;
   - *a*, unconscious, or[1]
   - *aa*, conscious, which is,
     - *b*, reflex, or
     - *bb*, directed by desire without ratiocination, or
     - *bbb*, by desire directed by reason.

The only general rules as to the direct influence of motion on structure which can be laid down at present are two, viz: That density of tissue is in direct ratio to pressure, up to a certain point;[2] and that excess of growth force, in a limited space, produces complications of the surfaces stimulated.[3] These and other laws, yet unknown, have probably led the changes expressed by evolution, while many others have followed the disturbance of equilibrium which they have produced.

I here allude incidentally to the question of transmission or inheritance. It has been maintained above that the bathmic force of each species is different from that of all other species. This force is characteristic of some unit of organization of living beings; and this probably consists of several molecules. This unit has been termed, by Haeckel, the plastidule. The transmission of the bathmic force of one generation to another would be effected by the transmission of one or more living plastidules; and this is probably precisely what is accomplished in reproduction. The *Dynamic Theory* of reproduction I proposed in 1871,[4] and it has been since adopted by Haeckel under the name of perigenesis. I compared the transmission of bathmic force to that of the phenomenon of combustion, which is a force conversion transmitted from substance to substance by contact. The recent observations of Hertwig, Bütschli and others, confirm this view. The theory of pangenesis, devised to explain the phenomenon of reproduction, is to my mind quite inadequate.

[1] Movements coming under this head are often called reflex.

[2] See *Penn Monthly*, 1872.

[3] "Method of Creation," Philadelphia, 1871.

[4] "Method of Creation," 1871.

EXPLANATION OF CUTS OF CRANIA OF ANURA.

The numbers in each column correspond with the types of ossification mentioned in the text, and are the same as those in the table of families given in the same connection. The power numbers attached to Fig. 3, represent the degree of ossification of the nasal bones, except the —1, which signifies unossified ethmoid. Most of the cuts are original.

BUFONIDÆ.—Fig. 2, anterior part of skull of *Chelydobatrachus gouldi* Gray, from Australia. Fig. 3, do of *Schismaderma carens* Smith, S. Africa. Fig. 6, top of head of *Peltaphryne peltacephala* D. and B., Cuba. Fig. 7, top of head of *Otaspis empusa* Cope, Cuba.

SCAPHIOPIDÆ AND PELOBATIDÆ.—Fig. 2, diagram of top of cranium of *Didocus calcaratus* Micahelles, Spain. Fig. 5, skull of *Scaphiopus holbrooki* Harl., United States. Fig. 6, skull of *Cultripes provincialis*, from France, after Dugès.

HYLIDÆ.—Fig. 1, *Thoropa misiessi* Bibr., Brazil. Fig, 2, *Hypsiboas doumerci* D. and B., Surinam. Fig. 2^1, *Hypsiboas punctatus* Schn., Brazil. Fig. 3^2, *Scytopis venulosus* Daudin, Brazil. Fig. 6, *Trachycephalus geographicus* D. and B., Brazil, after Steindachner.

CYSTIGNATHIDÆ.—Fig. 1, *Eusophus nebulosus* Gir., Chili. Fig. 2, *Borborocœtes tasmaniensis* Gthr., Tasmania. Fig. 3, *Elosia nasus* Licht., Brazil. Fig. 3^3, *Hylodes oxyrhynchus* D. and B., W. Indies. Fig. 4, *Grypiscus umbrinus* Cope, Brazil. Fig. 6, *Calyptocephalus gayi* D. & B., Chili.

RANIDÆ.—Fig. 3^1, *Ranula chrysoprasina* Cope, Costa Rica. Fig. 3, *Rana oxyrhyncha* Sund., S. Africa. Fig. 3^1, *Rana clamitans* Daud., N. America. Fig. 3^2, *Rana agilis* Mus., Berol. Fig. 3^3, *Rana hexadactyla* Less., India. Fig. 4, *Polypedates quadrilineatus* D. and B., Ceylon.

[*To be Continued.*]

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CONCERNING AMBER.[1]

BY ERMINNIE A. SMITH.

THE history of amber illustrates most clearly not only the slow and tedious growth of civilization, but also the seeming perversity and obtuseness of human nature, which, especially in former times, so retarded the advancement of science. Exhuming this history from the dim, far distant, prehistoric past, we find that from being first used for fuel by the almost barbaric northern hordes, among the more refined southern peoples, amber, like bronzes and their other articles of luxury, took the place of coin and had its economical and financial import. The oldest written documents that have come to us, mention it as one of the chief articles of luxury of the ancient civilized world, an object of greater request than fine gold.

[1] Read before the "American Asso. for the Advancement of Science," at Saratoga, August, 1879.